LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

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TEXTILE MILL LUBRICATION

PART I

From the Bale to the Spinner

THERE are few manufacturing plants more interesting to the average person than textile mills. The methodical and visable progress of the raw fibre in its passage to finished product will hold the attention of the most unmechanical layman, while the engineer finds in various intricate machines the highest development of mechanical genius. Likewise the lubricating engineer finds an opportunity to show his ability in decreasing the cost of production by eliminating friction from the thousands of bearings existing in the various types of machines. These bearings include all kinds of sliding motions and work at great range of speed from the rapidly whirling spindles to the slow-moving carriage. The proportional cost of power to total manufacturing cost is comparatively large in a textile plant, and as a large portion of the power is consumed in overcoming friction the importance of proper lubrication is great. In this article we shall show how the raw fibre is treated to make a finished product and how the requisite machines should be lubricated to get the best results.

In order to prepare the yarn or thread so that it will be in proper form and of correct texture for weaving, the raw fibre as received at the mill must undergo a long series of treatments which although more or less complicated in execution are simple in purpose. The matted mass of raw material as found in the bale must first be broken up and cleaned; the fibres must then be paralleled; and finally they must be drawn out, spun and given such other treatment as is necessary to produce the strength required for weaving. While the above brief outline gives the general course followed each process enumerated requires a number of intricate machines with thousands of bearings, the correct lubrication of which is a most important factor in the cost of operation. In outlining the proper lubrication of these machines we shall follow the process by steps considering each machine separately. The machines vary somewhat in different mills and also according to the character of the product and the texture desired, but the general scheme is the same in most manufacturing plants.

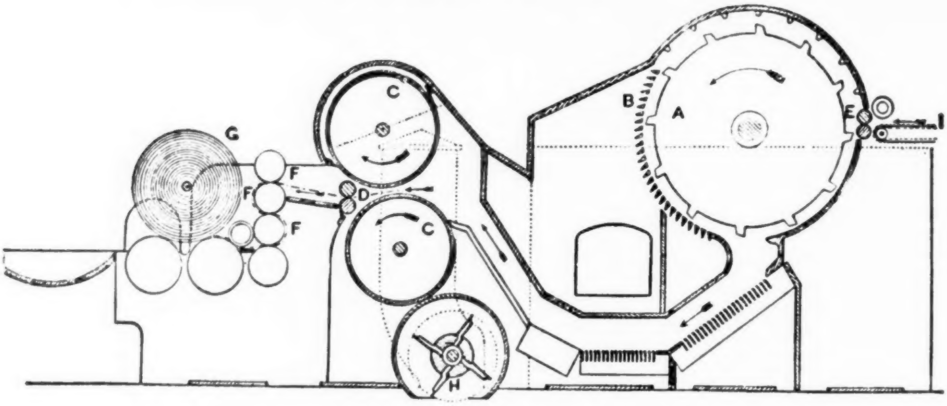


DIAGRAM OF OPENER

The first machine which tackles the raw stock is the bale breaker. This tears the compressed material into tufts by means of fast revolving aprons and cylinders equipped with protruding spikes. From this breaker the tufts are carried by conveyers or blown through pipes either first to large bins where they are thoroughly mixed to give uniform products, or are taken direct to a series of machines known as openers, breaker lappers, scutchers, intermediates, finishing lappers, etc. These machines may differ somewhat but they consist in principle of heavy cylinders equipped with protruding teeth or slats which seize the material and throw it forcibly against a grid. These beaters revolve at a speed of 1000 to 1800 revolutions per minute and not only beat out the dirt and foreign matter from the raw material, which falls through the grid, but separate the fibers. The worked stock is carried forward by suction or otherwise and finally is compressed by rollers into a sheet of batting. These sheets or laps are doubled and combined by superimposing the laps that come from several of the first machines in a series and passing them through a second machine where the combined lap is given another tearing apart and a further beating. This process of combining and tearing apart is continued through the whole series of openers and lappers until the fibres are completely broken up and the dirt removed. The sheet or lap then comes off soft and fluffy in a large roll which may be two or three feet in diameter and is ready for the carding machine.

Since in the above process the stock is often delivered to the next machine by air from a fast revolving fan, it is very important that the frictional temperature of the beater bearings be kept as low as possible. A spark would result in a quick blaze, and this would be blown all over the room in an instant. The origin of nearly every fire in a textile mill may be traced to this machinery and the opening room. A great many of the beaters in use today are equipped with ball bearings. These bearings may be satisfactorily lubricated with a pure mineral oil having a viscosity of from 200 to 300 seconds. There are a number of greases on the market manufactured especially for the lubrication of ball bearings, but most superintendents prefer an oil because it may be used for other purposes about the mill, thereby eliminating an extra brand to be remembered. The other bearings of the machinery in this room should be lubricated with an oil having a viscosity of 300 to 500 seconds, and the gears with a heavy, viscous grease which will stay in place, making frequent application unnecessary.

The lap or roll of batting received from the openers or lappers while quite clean may not be completely so. The fibres of the lap also are not parallel but lie in all directions and it is the function of the carding machine to straighten them, at the same time removing those which are knotted or unfit for use and also any impurities remaining in the lap. The basic principle involved is the straightening out of the fibers by combing or brushing them with wire brushes or cards. In the revolving flat card, which dominates the field today, there are, as a rule, three principal cylinders. The lap

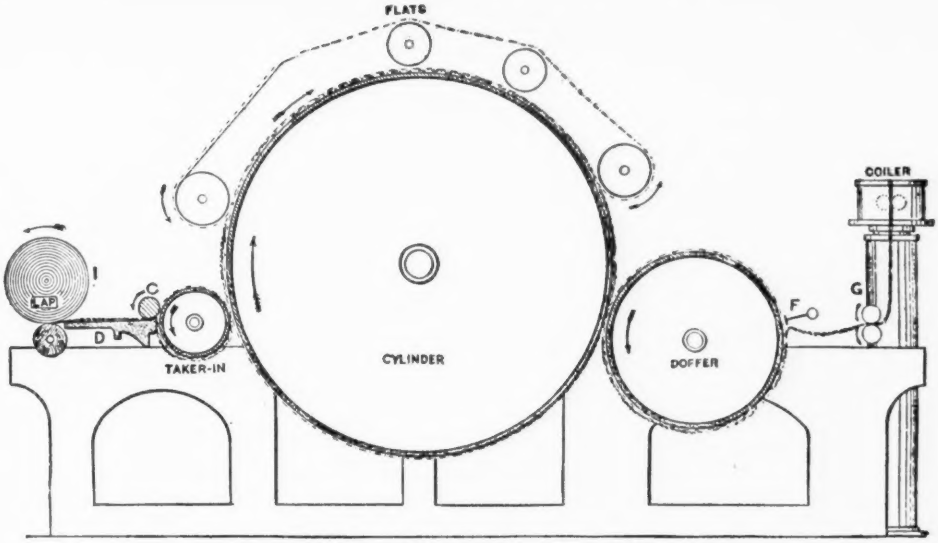
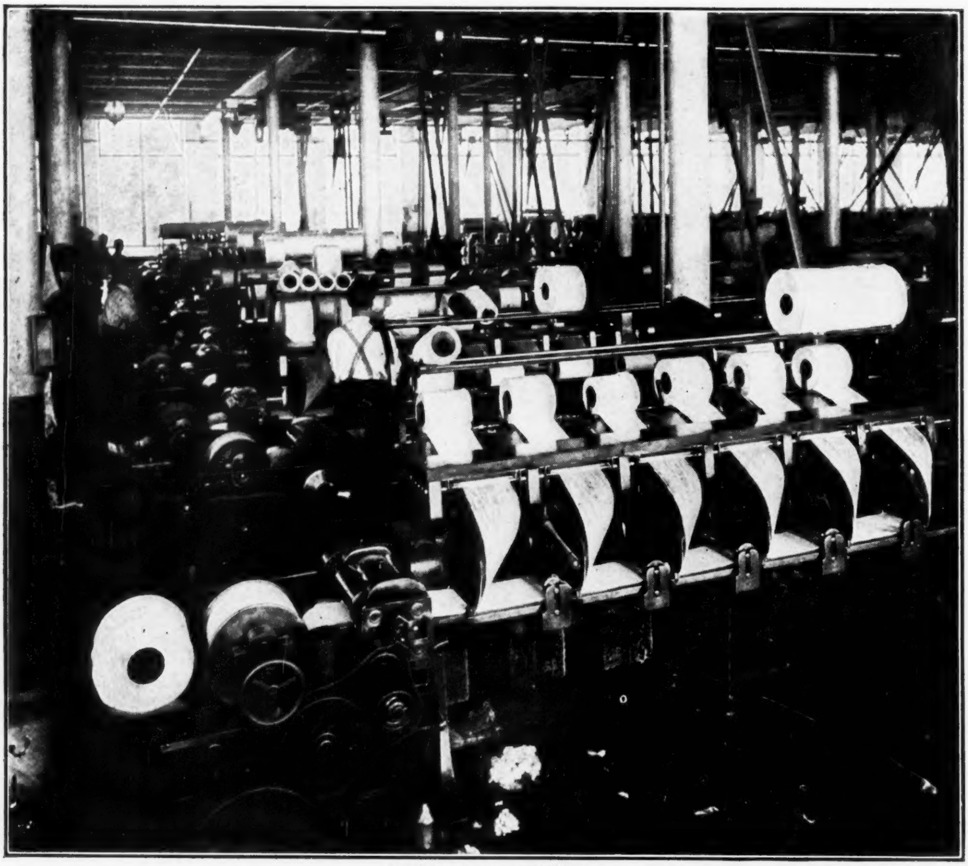


DIAGRAM OF CARDING MACHINE

passes first under the smallest of the three, called the taker-in, which is covered with very fine saw-teeth all in one long strip of steel, wound and fixed spirally in the surface of the cylinder. The taker-in receives the cotton from a feed-roller (C) that turns above a smooth iron plate (D) called the feed plate. The saw-teeth comb the fibers which are imbedded, so to speak, in the lap, and deliver the loose ones to the second cylinder, which is the largest of the group. This main cylinder is covered with wire teeth all bent at exactly the same angle. The cotton clings to them, and is carried around to the top of the cylinder, where it is engaged by teeth on the revolving, flat card which are bent in the opposite direction. This "card-clothing" arranged in strip, crosswise on a traveling lattice, moves in the same direction as the cylinder but moves very slowly, and so the fibres are carded between the two sets of wire points, the short and immature fibres remaining on the card wires of the lattice and the perfect and now almost parallel ones being carried over from the main cylinder to the doffer cylinder, the third of the trio. From this they are removed by an oscillating comb (F), coming off in a light fleecy lap, which is condensed through a funnel into a soft untwisted roping, or sliver, about the diameter of a man's thumb, and is then coiled into a can, usually about 45 inches high by 8 inches diameter.

It is of the greatest importance that the lubricant used on the bearings of this machine be carefully applied to prevent any getting on the card clothing. It might be said that with the exception of the comb box the other points of lubrication on this machine are few and comparatively simple, the comb box being the only point requiring unusual attention. This box contains an eccentric, and on some types there are two, driving the comber shaft at a speed of 1,500 to 2,200 revolutions per minute—a combined sliding and rotating movement. The eccentrics run in a bath of oil, and as the comb is usually set within 0.005 inches of the doffer cylinder, it is absolutely essential that this comb box within which the eccentrics are located be kept at an even temperature to insure adjustment of the correct distance of the comb from the doffer cylinder and the even running of the sliver. The successful lubrication of this box has long been a difficult problem, chiefly because of the fact that textile lubricating engineers have been completely in the dark as to the proper lubricant to use, and have invariably recommended a grease or non-fluid oil. With these high viscosity oils and greases low frictional temperatures could not be secured, and as a result economical operation was out of the question. Recent tests, however, have developed the fact that through the use of low-viscosity lubricants a very low frictional temperature can be shown, thus

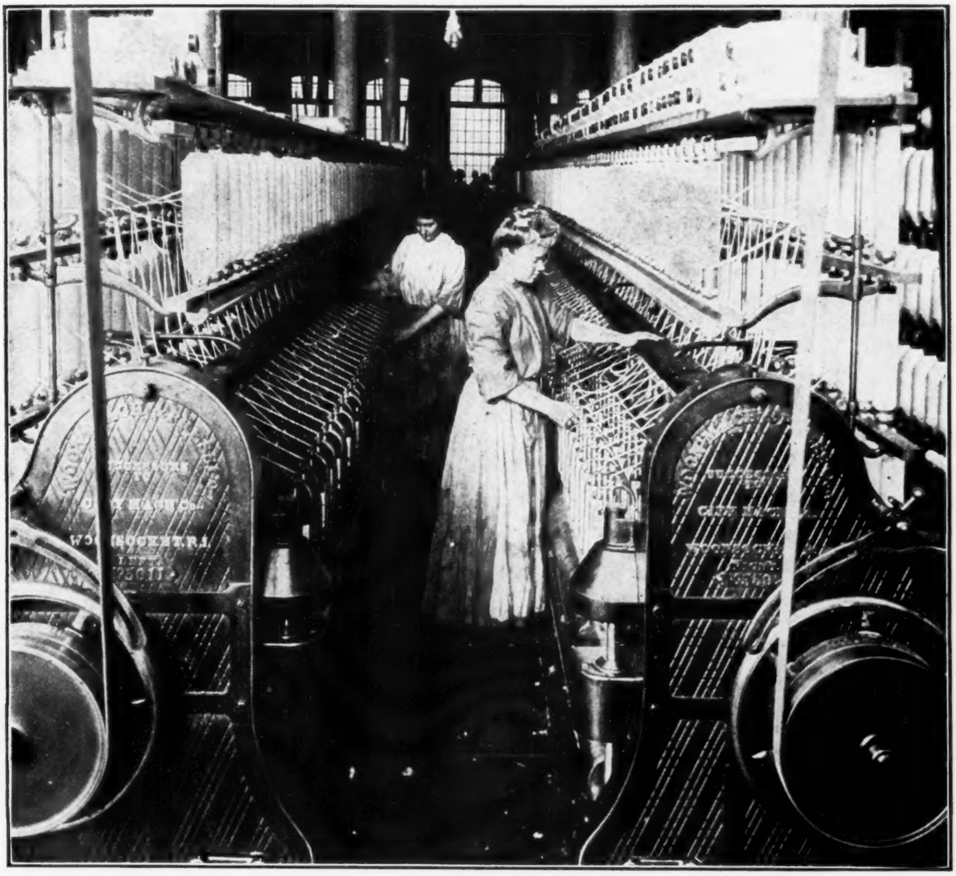


RIBBON LAPPERS

effecting a considerable saving in the cost of lubrication. In one test conducted by the writer, the initial application of the low-viscosity lubricant ran for sixty-five days and the average frictional temperature developed was 10.94 degrees Fahrenheit. Conditions in this mill were not unusual, and the carding machine in use was one of the most popular types manufactured. Owing to the fact that lubricants high in viscosity have been used for the lubrication of comb boxes since the carding machine was invented, considerable prejudice exists in the minds of the mill superintendents and card-room foremen with reference to the use of the low-viscosity lubricant, they having been educated to the belief that high viscosity oils alone would lubricate the box properly. During the several tests conducted by the writer, to demonstrate the superiority of a light over the heavy product, 534 readings were taken of the frictional temperature of the boxes, and the average was 21.61 degrees Fahrenheit, the average frictional temperature of the boxes containing the heavy lubricant being 36.53 degrees Fahrenheit. A more important feature, however, is the economical application of the low-viscosity lubricant, one filling lasting two and three times as long as the high-viscosity lubricant. All bearings on the carding machine should be kept clean and well supplied with an oil of 300 to 500 seconds viscosity twice daily. The cylinder and doffer shaft should be kept filled with a cup grease and should be inspected twice daily.

Some textile mills use a machine known as the tape condenser. This machine is used to rub the cotton from the carding machine direct into yarn ready for spinning. An oil ranging in viscosity from 300 to 500 seconds will lubricate this machine satisfactorily.

Another machine which has gained considerable prominence in recent years with textile mill owners is the combing machine, which is designed to improve the evenness, lustre, and



SLUBBERS

strength of the yarn by subjecting the laps to a combing and straightening process. When this machine is used two other machines are first necessary viz: the sliver lap machine and ribbon lap machine. In the sliver lapper the slivers from 14 to 20 cans are drawn side by side between three pairs of drawing rollers, reducing the size, and pass out between two pairs of calender rollers in the form of a lap about one foot wide. These laps are then passed to the ribbon lapper where six are unrolled simultaneously, each passed through drawing rolls, and then all six superimposed and calendered together into a lap about a foot wide.

If extra fine quality is desired the above process may be repeated as each drawing straightens the fibres and gives possibilities of finer spinning.

From the ribbon lapper the lap goes to the comber where the lap is combed with fine needle-like teeth ranging from 16 to 70 to the inch. The comber is so arranged that a number of laps go through simultaneously and are combined into a sliver which is deposited into cans similar to the sliver from carding machine.

The cam motions of the combing machine should be lubricated with a heavy, viscous grease, one which will withstand the heavy pounding of the cam finger, and which will not drip. The bearings on the combing machine and the bearings on the sliver lap and the ribbon lap machines may be lubricated with a 300 to 500-seconds viscosity oil.

The above processes have for their aim essentially the paralleling of fibres as a preparation for spinning. The sliver is light and fluffy and has practically no strength. To produce strength the sliver must be drawn and spun. With coarser yarns one or two drawings may be sufficient but with finer yarns the sliver must pass through a number of machines before

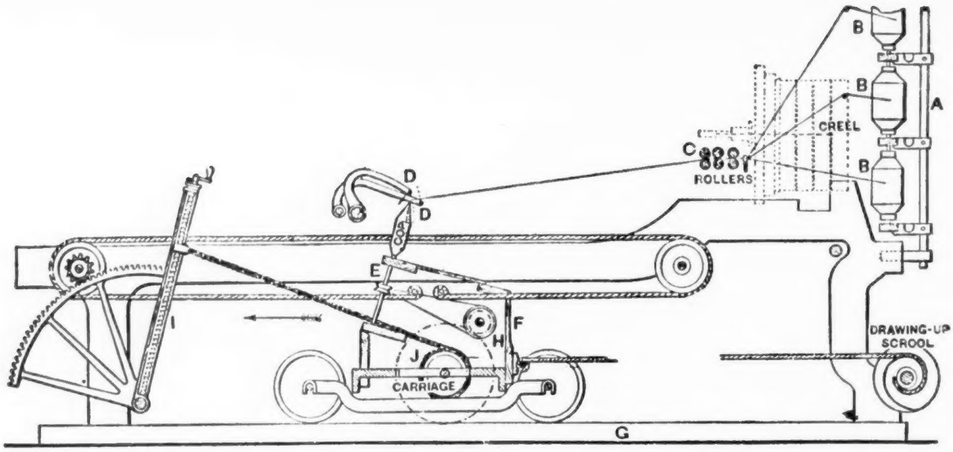


DIAGRAM OF MULE SPINNER

it becomes of proper texture to spin. These machines for each drawing are slightly different but the following are in general use: drawing frame, fly frame or slubber, intermediate frame, roving frame and jack frame. In the drawing frame the sliver from several cans, six or eight, are fed through one opening parallel into several pairs of rolls successively, each pair revolving at a greater speed than the previous pair. This changing of speed of the pairs of rolls draws out the combined sliver, making it more uniform in texture, and if the final speed is properly regulated the resulting sliver will be the same diameter as one of the original slivers fed in, and of a length equal to the combined lengths of the original slivers. This process of combining several slivers and drawing them out may be repeated several times in the same machine so that the final sliver may be made up of 216 original slivers doubled, drawn and combined.

The most important points of lubrication about these machines are the front rolls, through which the sliver passes in the drawing-out and straightening process. Very satisfactory results may be obtained through the use of a lubricant ranging in viscosity from 750 to 1,000 seconds, and it should be as nearly colorless as possible. This lubricant must not creep off on to the leather covering the rolls, as it will ruin the rolls and discolor the material. The draught gearing and cam tables of this machine should be lubricated with the same oil as is used on the rolls, and the bearings with an oil having a viscosity of 200 to 300 seconds.

From the drawing frame the sliver passes to the fly frame or slubber where the process of doubling and drawing is continued, but also the product is given a slight twist with a much less diameter, and is wound upon a spindle. The product is no longer called a sliver but the slubbing. From the slubber the product goes successively to the intermediates, the roving, and jack frame. Here the process of doubling drawing and slightly twisting is continued until the material is reduced in diameter to that of heavy twine and is wound upon bobbins ready for spinning. The material in passing these latter frames is called roving. The extent of the doubling undergone by the material in passing the various lappers and frames may be so great that the final unspun yarn is the product of 27,648 doublings from the original lap.

A 750 to 1000 seconds viscosity lubricant should be used to lubricate the roll necks, cams, differential motions and draught gearing on slubbers, intermediates, and jack roving frames, and the spindle steps of these machines should be lubricated with an oil having a viscosity of 200 to 300 seconds, and all other points may be satisfactorily lubricated with this same oil.

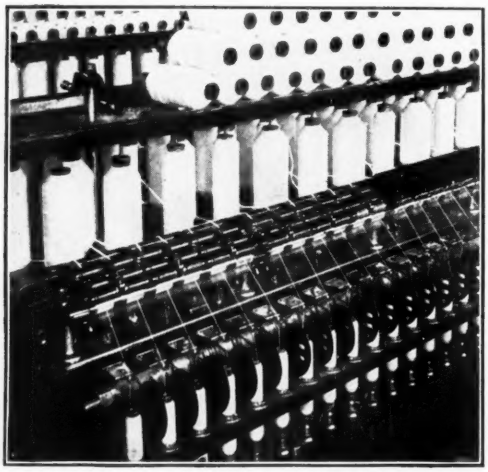
While the yarn from the roving frames is slightly twisted it is loose and still lacks the tensile strength necessary for weaving. This strength is given by spinning. There are, in general, two types of spinning machines; the mule spindle type used mostly abroad, and the ring spindle type used generally in the United States.

In the mule, which is a long and wide machine, carrying sometimes in new models as many as 1,300 spindles, the drawing and twisting are not continuous but consecutive. The rovings (B) are held on a creel (A) at the back of the machine, usually in three or four tiers, or on long beams or spools. They pass from the creel, or spools, between three pairs of drawing rollers (C). Coming out of the rollers, they are fed to the spindles on the carriage which backs away from the creel and recedes somewhat faster than the rovings are unwound. This receding is the essential motion of the mule, for thus the material receives it final drawing. The spindles, meanwhile, are revolving rapidly, spinning the yarn. The twist goes first to the thin places where the least resistance is offered. Then, as the carriage carrying the whirling spindles continues to back away, the thicker parts of the thread, being comparatively untwisted are pulled down to the average diameter and are twisted in turn. The carriage usually runs back about sixty-three inches. At the termination of its run, or stretch, the spindles increase their speed until the twisting is completed and the carriage starts on its return trip. This reverses the spindles, and the thread which has been wound upon them is unwound, the slack being taken up by one guide wire (D) while the other guides the thread to the winding point, and winds it up in the opposite direction on the cone-shaped cops on the spindles. The rollers do not feed out more roving as the carriage returns. Hence, there is no slack when the round trip is completed.

In the ring-spindle type, the spinning is continuous and not intermittent. The bobbins holding the roving are placed directly over the spindles. Around each of the latter is a steel ring. There are at least 112 spindles on each machine, and all the machine rings for the spindles are fixed in a single frame. The upper edge of the ring is flanged (like a minature rail of a railroad track) and snapped over the flange is a small but important C-shaped steel ring, called the traveler. When the machine is in operation each roving (H) leaving its bobbin runs through the usual drawing rollers (G) then through a guiding wire to the ring, where it is passed through its traveler (B) which is always at the winding point on the spindle. As the spindle and the rollers revolve, the roving is fed out at a considerable slower rate than the spindle takes it up, so that there is always a tension on the thread. The whirling spindle thus pulls on the traveler, drawing it round and round on its flanged track (A). It revolves just a little more slowly than the spindle and thus the yarn receives its twist. Meanwhile, the frame (C) on which the rings are fixed moves slowly up and down, so that the winding is properly regulated.

Fully ninety-five percent of the textile mill superintendents and purchasing agents in this country today judge the ability of a refiner to furnish satisfaction by the performance of the spindle lubricant submitted, and textile lubricating engineers devote more time to the lubrication of spindles than to the lubrication of all the rest of the machines in the mill. The speed of a spindle ranges from 3,000 to 14,000 revolutions per minute, depending upon the number of the yarn being spun. One horse-power is supposed to drive from 62 to 68 spindles, but it is impossible to keep within this limit unless the proper oil is used. It is essential that spindles be lubricated with oils especially prepared for that purpose. These oils must be limpid and free-flowing. They must, however, possess sufficient viscosity to form a protective film of lubricant between the bolster and the spindle. There are a number of different types of ring spindles on the market today, but their principle of construction is so nearly the same that one oil of the proper specifications will successfully lubricate all, except when there is a considerable difference in size and diameter of the whorl. The following specifications include the oil suitable for the lubrication of any type of ring spindle:

	Light Spindle Oil No. 1	Light Spindle Oil No. 2	Regular Spindle Oil	Heavy Spindle Oil
Flash ...... Not under	275 degrees	275 degrees	275 degrees	300 degrees
Viscosity at 100 degrees F. Saybolt Univ.	60 seconds	70 seconds	75 seconds	100 seconds



RING SPINNING FRAME

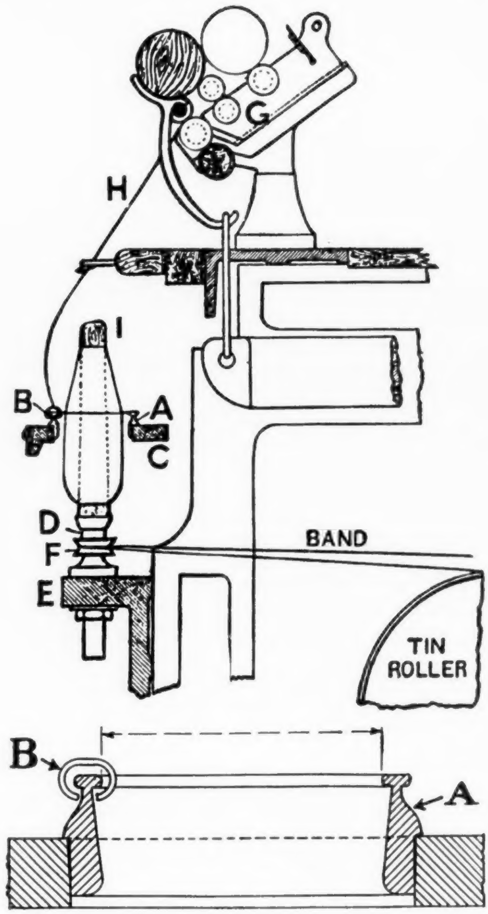


DIAGRAM OF RING SPINDLE

Spindles should be lubricated twice monthly and the bases cleaned every time the frame is leveled, which should be at least once each year. Another factor largely responsible for the good or bad performance of the spindle is the tension of the cotton band driving the spindle. If the band is too tight it causes unnecessary friction in the base, and increased power consumption. If it is too loose it will slip on the whorl and make soft places in the thread. Bands on whorls should have a tension, or band pull, of two and one-half pounds. Through the use of tape drives on spinning frames a more constant band pull is assured, and since they last so much longer they are much more economical than the cotton band. The top rolls of the spinning frame should be lubricated with the same lubricant used for the rolls of the drawing and roving frames, and the bearings with an oil having a viscosity of 200 to 300 seconds. When very high yarn numbers are required the mule spinning frame is generally used, and the most important point of lubrication is the spindle base. These bases are open, and for that reason the lubrication of this spindle is comparatively simple. The oil should not be too heavy, else it will cause internal friction, but it should be heavy enough to stick in the base, and not throw. An oil having a viscosity of 150 to 200 seconds will lubricate the base satisfactorily. Some mills using both ring and mule frames buy ring spindle oil only and use it on both the ring and the mule frames, but this practice does not insure the best results on both types. The same lubricant used for the rolls of the ring frame will function perfectly on the mule rolls, and the bearing lubricant should be the same as the ring spinning frame bearing lubricant.

While the fibre is now spun into yarn it is not entirely ready for weaving. It must receive further treatment so that it will be sufficiently strengthened and be in proper form for use in the loom. This treatment and the mechanism and lubrication of looms and printing machines will be taken up in a subsequent article.

We take this occasion to express our indebtedness to the Guaranty Trust Company, who loaned us the illustrations appearing in this article. These, as well as a good deal of the data, has been taken from their splendid publication, "The Fabric of Civilization."—Editor.

Cement Mill Lubrication

PART III

In LUBRICATION for May we discussed the lubrication of crushing and drying machinery. In the June issue we continued the discussion to the raw side pulverizing machinery and the kilns. We are now ready to describe the lubrication of the machines employed in reducing the clinker to the fine gray powder which we all know as Portland cement.

Many different varieties and combinations of mills are employed for clinker grinding. Some of these combinations include the ball and tube mills which were discussed in the June installment of this article.

In some plants the clinkers issuing from the cooler are too large for immediate grinding in the pulverizing mills. It is then necessary first to reduce them to a more convenient size. A very effective way of accomplishing this is by constructing a rough ball mill in the lower end of the cooler. A few plants reduce the clinker in crushing rolls or pot crushers.

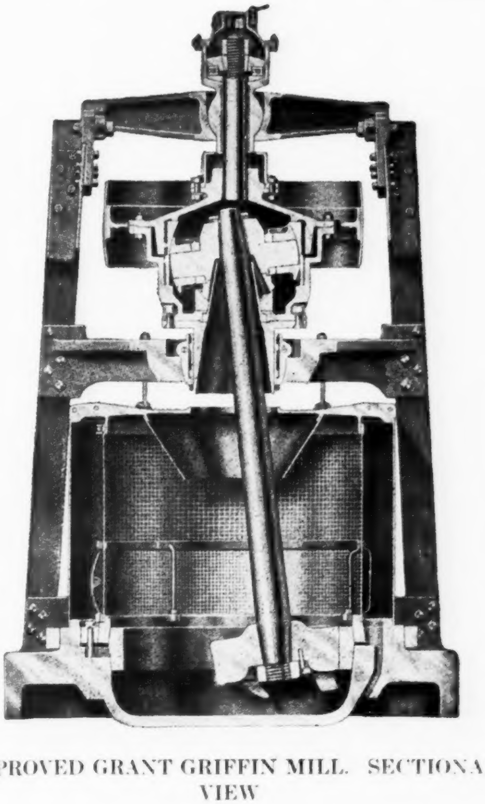
Crushing, or mining rolls, are simply two heavy cylinders with smooth or corrugated faces which are held together by means of large springs so that the rolls may be pressed together with great force and yet be free to separate when material which they cannot crush comes between them. Gears are seldom used to drive these rolls, a large pulley usually being keyed to the shaft of each roll. Because of the heavy service the shafts are unusually large and the bearings are not made with any attempt at extreme refinement. They are long and heavy and usually of the split type, babbitted all the way around although semi-enclosed bearings and removable brasses are used in some cases. When grease lubrication is not employed a small reservoir is provided on the top half of the bearing and this should be kept filled with waste soaked with black oil or heavy crusher oil. The waste will serve to keep a great deal of dust out of the bearings as well as to regulate the oil feed. Because of the heavy, uneven loads coming upon the bearings of roll crushers they should be kept flooded with oil.

In some few remote cases pot crushers are employed instead of rolls. These reduce the clinkers in a manner similar to a small hand coffee mill.

Pot crushers are roughly constructed and may be successfully lubricated throughout with either black oil, crusher oil or cup grease, although the life of the gears may be greatly prolonged by lubricating them with a heavy, adhesive grease capable of keeping dust and grit away from the bearing surfaces.

The Fuller-Lehigh mill which has already been discussed under raw-side grinding is also used for clinker grinding.

A mill which crushes upon a horizontal anvil ring in much the same way as the Fuller-Lehigh mill and which also utilizes centrifugal force in the crushing process is the Griffin mill. The construction of this mill is shown very clearly in the accompanying illustration.

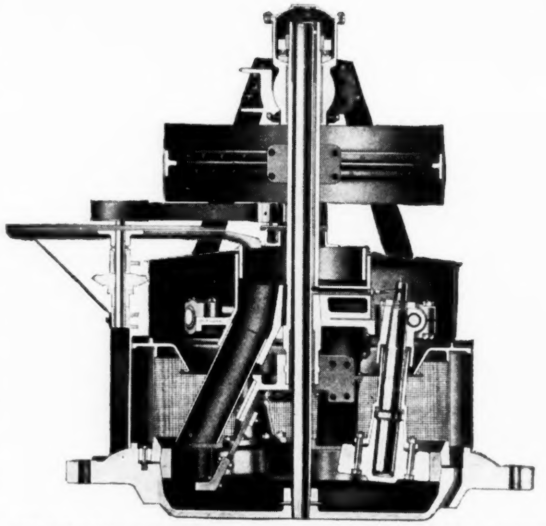


IMPROVED GRANT GRIFFIN MILL. SECTIONAL VIEW

All the working parts are suspended from a thrust bearing located in the spider at the top of this machine. When the horizontal pulley revolves it causes the working parts to revolve with it. With accelerated speed the hammer roll fixed to the end of the suspended shaft is gradually swung outward and is finally pressed against the anvil ring with great force. The material fed into the grinding compartment is struck by a spade on the bottom of the hammer roll and thrown upon the surface of the anvil ring in the path of the hammer roll by which it is crushed. Material which is sufficiently pulverized is thrown through the screen which surrounds the grinding chamber.

In the Griffin mill all the wearing parts except the lower bearing run in a bath of oil and provision is made for excluding the dust and grit which is sometimes very thick about a pulverizing mill. An oil passage is provided between the thrust bearing chamber and the pulley case so that oil fed in at the top of the former gradually feeds down into the latter. The thrust bearing, which is of the ball bearing type, carries the whole weight of the moving parts and is the hardest to lubricate. The motion in the pulley case is very slight although the loads here are quite heavy. The primary requisite of an oil for these bearings is that it should be heavy. A great many Griffin mills are lubricated with cylinder oil, but because of the tendency of the fatty matter in cylinder oils to decompose and liberate acids which attack the polished surfaces of ball bearings, better results would probably be obtained through the use of a good quality of heavy engine or machine oil. The lower bearing is arranged for cup grease lubrication as oils drip from this bearing into the grinding chamber below. Very little trouble is experienced in lubricating this mill unless grit is allowed to get into the oil chambers. This can only happen when the cover of the thrust bearing chamber is left open carelessly or dirty oil is used.

Another mill of the centrifugal type much used for clinker grinding is the Bradley Hercules mill. This mill pulverizes in much the same way as the Griffin mill described



BRADLEY HERCULES MILL. SECTIONAL VIEW

above, three rolls being used instead of one, however. The arrangement of the rolls is so clearly shown in the illustration that it needs no further description.

Oil is fed by gravity to all the main working parts from the thrust bearing chamber at the top of the machine. Passing the upper bushing the oil moves down between the quill shaft and the center post. Some goes to lubricate the lower bushing but the greater part flows through the flexible tubes and down the centers of the roll shafts from which it issues and lubricates the bearings of the rolls. The chief requirement of an oil for this machine is a good body at fairly high temperatures as the heat from the clinkers being ground often causes the hammer rolls to get quite hot. A heavy bodied engine or machine oil may be successfully used upon the Hercules mill. Cylinder oil also is found satisfactory but cylinder oils are always objectionable when ball bearings are used. A light oil should under no circumstances be placed in either the Griffin or Hercules mills. Not only will light oils fail to keep the bearing surfaces apart but they feed too rapidly and are liable to flood the lower parts and leak out into the grinding chamber. This may also happen if too much oil is poured into the reservoir at one time. Great care should be taken to see that no dust or clinkers are allowed to enter the oil chamber at the top of the machine as

these may plug the oil passages and also cause rapid wear and heating.

A mill which operates upon much the same principle as the Hercules mill is the Huntington mill. The Huntington mill originally designed for ore crushing, has been tried for clinker grinding. It is not suitable for this work, however, and to our knowledge has been employed by only one company.

The mills so far discussed, all grind upon a horizontal anvil ring and obtain the grinding pressure through centrifugal action. We shall now turn to a type of machine which grinds upon a vertical ring and obtains the grinding pressure from springs. These are the Sturtevant and Kent mills.

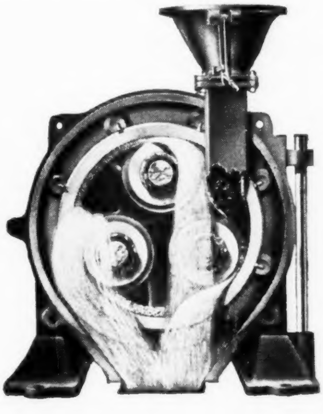
The accompanying cuts clearly illustrate the construction and action of the Sturtevant mill. A steel anvil ring is supported and revolved by a large horizontal shaft driven by gears. Against the inner surface of the anvil ring three hammer rolls are held by means of springs. The material to be ground is delivered to the anvil ring through a spout and held upon the surface of the ring by centrifugal force. Passing between the rings and the rolls the material is pulverized, some of it being thrown into the hopper at the bottom of the machine. From this point the material is conveyed to external screens where that insufficiently ground is separated and returned to the mill for further reduction. The points requiring lubrication in this mill are the hammer roll bearings, the ring shaft bearings, the pinion shaft bearings, and the teeth of the gears.

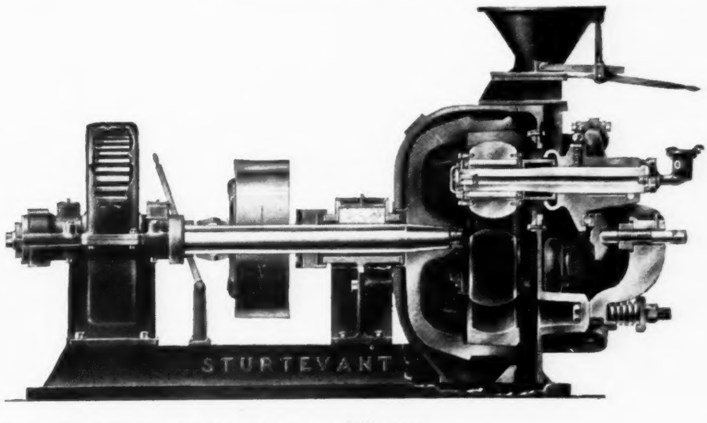
As will be observed the hammer rolls are mounted upon roller bearings. The rollers are enclosed in a dust-proof chamber and operate in a bath of oil, the oil being fed from a large reservoir fixed to the end of the hammer roll shaft. The oil used for the roller bearing lubrication should be a neutral straight run product. Compounded oils are liable to become rancid and gum up the rollers in the presence of the heat which obtains in the interior of this machine. The use of an oil possessing considerable viscosity is necessary also in order that it may retain enough body to prevent metal contact at operating temperatures. It is essential that the hammer roll bearings be kept flooded with oil.

The ring-shaft bearings offer no unusual difficulties and if kept free from dust will give no trouble. The maximum speed of the shaft is only 125 R. P. M. and the load is well balanced. These bearings are equipped with large openings at the top which may be packed with oil-saturated waste or a light grease. A good quality of black oil will prove satisfactory here.

The pinion shaft operates at a somewhat higher speed than the ring shaft but the same provisions are made for lubrication and the same oil may be used.

The gears of the Sturtevant mill are enclosed and consequently dust does not have to be contended with as in the case of the kilns, etc. In addition they are not exposed to high temperatures. These gears may be operated in a bath of black oil or lubricated by means of a heavy gear grease provided it





STURTEVANT MILL. FRONT AND END VIEW

possesses sufficient adhesiveness to prevent its being thrown off by centrifugal force.

A pulverizer which crushes in exactly the same manner as the Sturtevant mill is the Kent mill. This mill is driven in a somewhat different manner, however. Instead of the ring being driven as in the Sturtevant mill the top hammer roll is driven by means of a pulley or directly by a motor. The movement of the top roll forces the ring to revolve and the ring in turn imparts motion to the lower rolls. There are but six points requiring lubrication on the Kent mill, viz., two bearings on each of the three hammer roll shafts. These bearings are long and are fitted with collars for excluding dust. Each bearing is equipped with a large reservoir capable of holding a quantity of grease which is fed into grooves on the slack side of the bearing. This machine presents no unusual lubricating difficulties and may be lubricated throughout with a light grease. Oil is not recommended for the bearings of the Kent mill because it drains out too rapidly and is liable to become mixed with the material being ground.

In preparing the coal for the kilns the same machines are employed which we have described under clinker grinding. Crusher rolls, hammer mills, tube mills, and small rotary dryers are also used but lubrication is no different here from that in other parts of the plant.

Many types of elevators and conveyors are used about the cement plant. These are for the most part driven by exposed gears, although some are driven by sprocket wheels and chains and some by belt and pulley. The shaft bearings of elevators and conveyors are usually lubricated with cup grease. Cup grease proves a very satisfactory lubricant for this purpose and because of the inaccessibility of some of the bearings the only lubricant practical.

Due to the abrasive action of the dust and grit which is constantly falling upon them, gears wear rapidly unless properly lubricated. The dust also has a tendency to dry up the lubricant on the teeth and will cut through a light oil causing about as much wear as if no lubricant were used at all. In addition many elevator and conveyor drives are exposed to considerable heat and in some cases to water. To successfully protect gears under these conditions, a lubricant should possess enough body to keep the wearing surfaces apart and protect them from grit. It should be unaffected by high or low temperatures and cling to the teeth at all speeds. It also should resist the washing action of water and because of the inaccessibility of some of the gears one application should last for a period.

The chief requirements of the lubricant used on the sprocket wheels and chains are that it penetrates between all wearing parts of the chain, that it prevents metal contact and abrasion by grit and cling to the wheels and chains at all speeds and temperatures.

A great deal of the miscellaneous shafting about the cement plant may be lubricated with black oil. In cases where temperatures are high or the loads heavy, cup grease may prove more efficient. When shafting speeds are high a medium bodied engine oil will be found more satisfactory than either black oil or cup grease. Every effort should be made to keep dust out of shafting bearings.

In addition to the machines described in this article many steam engines, steam turbines, dynamos, motors, pumps, blowers, etc., are employed about the cement plant. We can not hope to discuss these here but from time to time we shall publish articles dealing with their lubrication.

Lubrication in the Portland cement mill has been treated with but indifferent attention in the past, but the bearing which lubrication has upon operating costs is now fully recognized. One of the largest items in the cost of manufacturing Portland cement is the expense incurred in purchasing, replacing and repairing equipment. The care taken of the machinery has a large influence upon this item, and in the cement mill proper care is to a large extent proper lubrication.

NOTE. *The Bureau of Standards of Washington suggests that we call attention of our readers of the article on VISCOSITY appearing in our July issue that equation III, Page 4, does not hold below 32 seconds, and therefore, Saybolt instruments should not be calibrated with water. While this point was implied in the article it was not specifically emphasized and we thank the Bureau of Standards for bringing it to our notice so that we can call particular attention to this necessary characteristic of the instrument.*